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SOFT TISSUE ATTACHMENT SYSTM AND METHOD

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SOFT TISSUE ATTACHMENT SYSTEM AND METHOD

Background of the Invention

The present invention relates to orthopaedic implants and procedures in which a portion of bone is removed to which soft tissues, such as ligaments and tendons, are attached. In particular, the invention relates to systems and methods for maintaining the soft tissue attachment during an orthopaedic procedure.

Certain orthopaedic surgeries, such as hip surgeries, often require osteotomies of a portion of the femur to provide full access to the hip joint. In these procedures, a portion of the greater trochanter is removed. Following the surgery, the removed bone portion is replaced and secured in a number of ways. For instance, trochanter reattachment systems can include wiring, cables or clamps that are used to hold the removed portion to the retained bone long enough to promote healing through fusion.

In some orthopaedic procedures, a significant portion of a joint is replaced with a prosthesis. For instance, in some hip surgeries, the entire proximal portion of the femur is removed and replaced with the prosthesis. Since the attachment point for the soft tissue is removed with the bone, surgeons have turned to composite allograft-endoprosthesis constructs to provide a foundation for connection of the soft tissue to the implant. Usually, the soft tissue, such as tendons, are connection by sutures, so that the resulting connection is only as strong as the suture. The success of these types of reconstruction is historically low.

What is needed is a system and method that preserves as much of the natural attachment point for soft tissue as possible. An optimum approach would make use of as much of the natural bone as possible so that the attachment of the soft tissue to the bone is not compromised or replaced by a less secure attachment.

Summary of the Invention

In view of these needs, the present invention contemplates a system and method in which the natural removed bone is retained, along with the natural attachment of the associated soft tissues. For instance, in a hip surgery, a portion of the greater trochanter is removed while retaining the soft tissue attachments. The present invention provides means for receiving that bone portion and connecting it to a proximal femoral implant, for instance.

In one embodiment of the invention, the implant and bone portion are provided with mating features, such as a keystone configuration. The keystone configuration can include mating male and female dovetail configurations. The bone portion can be engaged to the mating feature of the implant to support the natural bone and its soft tissue attachment in an anatomically appropriate position.

In a preferred embodiment, the keystone and dovetail features are angled inward so that the natural tensile forces exerted on the bone portion will tend to force the male/female features into tighter engagement. In another feature, the implant can include a bone ingrowth surface at the interface to the bone portion to enhance the fixation of the natural bone to the implant.

In certain embodiments, separate fixation elements are provided to ensure a tight connection between the bone portion and the implant. In one embodiment, one or more cables can encircle the bone portion to hold the portion in position without interfering with the soft tissue and soft tissue attachments. In another embodiment, a hinged claw scaffold can be provided that can be pivoted into engagement with the bone portion. The scaffold can include claws to penetrate the bone. The scaffold can also include plate portions through which bone screws are driven into the underlying bone. The scaffold can also be configured to integrate with cables encircling the bone portion.

In a method of the invention, the portion of a bone, such as the femur, is removed as necessary to accept a prosthesis or implant, such as a proximal

femoral implant. Certain portions of the removed bone that include soft tissue attachment points can be removed separately, while retaining the attachment to the soft tissues. The removed portion of the bone can be engaged within a cutting jig that is configured to permit forming the mating feature in the cut surface of the removed bone. The mating feature cut into the bone is complementary to a mating feature defined in an exposed surface of the implant.

In accordance with this method, the prosthesis is implanted within the remaining natural bone, with the exposed surface in proper alignment to accept the removed bone. The mating feature of the removed bone is engaged to the mating feature on the implant, while the soft tissue remains attached to the natural removed bone. Additional mechanical fixation can be provided to ensure a firm connection between the removed bone and the prosthesis as the surgical site heals.

It is one important object of the invention to provide a system and method for removal of portions of a bone, while retaining other portions of the bone bearing soft tissue attachments. A further object is to provide means for conducting complex orthopaedic surgical procedures, such as joint arthroplasty, while preserving the natural soft tissue and soft tissue attachment points.

Other objects and particular benefits of the present invention will become apparent upon consideration of the following written description and accompanying figures.

Description of the Preferred Embodiments

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same should be considered as illustrative and not restrictive in character. It is understood that only the preferred embodiments have been presented and that all changes, modifications and further applications that come within the spirit of the invention are desired to be protected.

For illustrative purposes, the preferred embodiments of the present invention will be explained in the context of an orthopaedic joint arthroplasty procedure for the hip joint involving the proximal portion of the femur, as depicted in **FIG. 1**. It is understood, of course, that the principles discussed herein can be applied to other joints and bones of the body. In the context of the present invention, one goal is to preserve the soft tissue attachments to portions of natural bone. It is further understood that features of the present invention can be utilized even where soft tissue attachments are not a concern.

As shown in **FIG. 1**, a bone, such as the femur, includes a shaft **S** terminating in a proximal portion **P** that is configured to form an articulating component of a joint, such as the hip joint. To that end, the proximal portion includes a neck **N** supporting a head **H** that provides the articulating surface. In the case of a femur, the head **H** is a ball joint component. Various soft tissues, such as flexor tissues, are connected to the bone at the proximal portion P, particularly at the greater trochanter **T**. The trochanter includes various soft tissue attachment points **T** for tendons associated with muscles of the hip joint, such as certain gluteal muscles.

In certain orthopaedic procedures, the proximal portion **P** of the femur is removed, as depicted by the dashed lines in **FIG. 2**. A bore **B** is formed in the bone shaft **S** to receive portions of an implant or prosthesis, such as the proximal prosthesis shown in **FIG. 3**. In a typical procedure, the trochanter **T** is removed with the proximal portion, and the soft tissue attachments severed. In some procedures, it is possible to integrate an allograft component with the prosthesis,

and then to suture the soft tissues to the allograft component, thereby restoring the soft tissue attachment to the bone.

The prosthesis **10** can be similar to known designs for use in hip joint arthroplasty procedures. For instance, the prosthesis **10** can include a body **11** that is configured to approximate the removed proximal portion **P** of the femur. The body defines a neck **12** onto which a prosthetic articulating component of known design can be mounted. The prosthesis also includes a stem **13** that is implanted within the bore **B** to fix the prosthesis to the bone.

While prior hip joint prostheses include a body that emulates the shape of the trochanter, the present invention contemplates that the body **11** defines a mounting platform **15** that is arranged to coincide with the surface of the proximal portion **P** remaining after the trochanter **T** has been removed therefrom (see **FIG. 2**). This mounting platform **15** defines surface features for mating engagement with the removed portion of the trochanter **T**. As shown in **FIG. 3**, the attachment point **A** for certain flexor tissues **F** is maintained even as the trochanter portion **T** is engaged to the mounting platform.

In one aspect of the invention, the mounting platform and the bone portion **T** define mechanical engagement or mating features that allow the bone portion to be engaged to the prosthesis **10** when the prosthesis is in its implanted position. As shown in **FIGS. 4** and **5**, the mounting platform defines a keystone slot **17** with a dovetail undercut **19** (best seen in **FIG. 5**). The slot includes a mating surface **21** that is in direct contact with the bone portion **T**.

The bone portion **T** is cut to define a mating feature **25**, as illustrated in **FIGS. 6** and **7**. The mating feature includes a dovetail cut **27** at opposite sides of a mating surface **28**. In the illustrated embodiment, the mating feature **25** is a male feature that projects from the cut surface **C** of the bone portion **T** and that is configured for interlocking engagement with a female feature **17** defined in the mounting platform **15** of the prosthesis. Alternatively, the male and female features can be swapped between the prosthesis and the bone portion, or a combination of male and female features can be defined on each component.

The dovetail elements, i.e., the undercut **19** and cut **27**, are formed at a converging angle **M**. This converging feature provides a natural stop for insertion of the male mating feature **25** of the bone portion **T** into the female feature **17** of the prosthesis. In other words, once the prosthesis has been implanted, the bone portion **T** can be mounted to the prosthesis by sliding the mating feature **25** into the keystone slot **17**. The bone portion is firmly engaged to the prosthesis when the angled walls of the dovetail cut **27** are flush with the complementary angled walls of the dovetail undercut **19**. The converging angle **M** can be a Morse angle to enhance the engagement between the bone and the prosthesis.

As shown in **FIG. 4**, the keystone slot **17** can extend along the entire length of the mounting platform **15**, as depicted in **FIG. 4**. Similarly, the mating feature **25** cut into the bone portion **T** can extend along the entire cut surface **C**, as represented by the dashed lines in **FIG. 6**. It is preferable that the extended mating features **17**, **25** be fully complementary so that the male feature resides entirely and firmly within the female feature when the bone portion **T** is finally mounted to the prosthesis **10**.

In the present embodiment, the fixation between the prosthesis and the bone portion is accomplished by the mating features **17** and **25**. The mating surface **21** of the prosthesis contacts the mating surface **25** of the bone portion **T**. Preferably, the prosthesis mating surface **21** includes a bone ingrowth feature to permit bone ingrowth from the bone portion **T** into the prosthesis. The bone ingrowth feature can include a porous surface that can be filled with a bone growth promoting or enhancing material, such as bone morphogenic protein.

In some instances, additional mechanical fixation may be desirable. In these cases, one embodiment of the invention contemplates the use of one or more cables that encircle the bone portion, in the nature of a cerclage device. Thus, as shown in **FIG. 8**, a prosthesis body **31** can be provided with a keystone slot **33**, configured as described above. The body can define angled surfaces **36** on opposite sides of the keystone slot **33**. A bore **35** passes through the body beneath the slot **33**, as depicted in **FIG. 8**, opening at each of the angled

surfaces **36**. The bore is sized to receive a cable or wire **37** passing therethrough. One end of the cable **37** can carry a crimp **39** that can be crimped onto the opposite free end of the cable when it encircles the bone portion **T**. The cable can be tightened in a conventional manner, such as the manner in which a cerclage wire is tightened. The crimp **39** can also be of known design to firmly and permanently connect the ends of the cable. The cable **37** thus adds an additional mechanical fixation to hold the bone portion **T** to the prosthesis body **31**.

An alternative mechanical fastener is depicted in **FIGS. 9-10**. In this embodiment, a prosthesis body **41** defines a mounting platform **43** on which the bone portion **T** is mounted. The platform **43** can define a mating feature, such as the keystone slot **17** described above, to engage a corresponding mating feature on the bone portion, such as the dovetail feature **25**. A scaffold **45** is mounted to the platform **43**. In a specific embodiment, the platform defines a slot **47** for receiving an axle **50** of the scaffold. The slot and axle can be configured to permit pivoting of the scaffold from a position clear of the mounting platform **43**, to permit mounting of the bone portion **T** thereon, to a position engaging the bone portion, as shown in **FIG. 9**.

The scaffold **45** includes at least two arms **55** that are configured to generally conform to the profile of the bone portion **T**. The arms **55** can include several claws **49** configured to penetrate at least the cortical layer of the bone portion **T**. The claws **49** are shown at the tip of the arms **55** in **FIG. 9**, but could be situated at different locations along the scaffold. The claws **49** provide means for engaging the scaffold to the bone portion to hold the portion in position on the prosthesis.

In an alternative embodiment, the scaffold **45** can include cross bars **57** spanning between the arms **55**, as can be seen best in **FIG. 10**. The cross bars **57** provide a support surface for bone screws **52** passing through the cross bars into the underlying bone, as shown in **FIG. 9**. The bone screws **52** can be used in addition to or in lieu of the claws **49** described above. While only two bone

screws are illustrated in the **FIGS. 9-10**, fewer or greater numbers of screws can be utilized. In addition, as shown in **FIG. 9**, the screws are sized to penetrate only part way into the bone portion **T**. Alternatively, the screws can be sized to pass entirely through the bone portion and engage a corresponding screw bore (not shown) formed in the mounting platform **43** of the prosthesis body **41**.

As a further alternative, the cable system shown in **FIG. 8** can be integrated with the scaffold **45** of **FIGS. 9-10**. In this alternative, the cable crimps **39** can be configured to include a bore (not shown) through which the bone screws **52** can pass. With this feature, the cable crimps can be connected to the scaffold to solidly hold the bone portion **T** to the prosthesis.

The present invention also contemplates a system for preparing the removed bone portion **T** to add the mating feature **25**. Thus, a cutting jig **70** can be provided as shown in **FIG. 11**. The jig includes two arms **82**, **83** to clamp the bone portion therebetween. Both arms can be provided with spikes **74** to penetrate and grip the bone portion. The arm **82** defines a support base **72** to hold the proximal portion of the bone with the cut surface **C** (**FIG. 6**) facing a guide plate **76** carried by the opposite arm **83**. The support base **72** can be shaped to conform to the profile of the bone portion.

The guide plate **76** defines a number of slots **78** that act as guides for saw blades, such as the blades **85** shown in **FIG. 12**. The slots are arranged as necessary to create the dovetail cuts **27** in the cut surface **C** of the bone. In the even that the dovetail cuts extend along the entire length of the bone portion, the slots **79** can be extended accordingly, as indicated by the dashed lines in **FIG. 11**.

In one embodiment, the cutting jig **70** is in the form of a manual scissors-type tool. Thus, the two arms can be connected at a pivot **87**, as shown in **FIG. 12**, and can include grippable handles **89**, **90**. The cutting jig can thus be manipulated by the surgeon with one hand, while the cutting blades **85** are manipulated with the other hand. Of course, it is understood that the cutting jig **70** is not the only way that the bone portion can be fashioned with the mating

feature **25**. Any other technique for making the necessary cuts are contemplated, provided these cuts can be *in situ* made with the bone portion **T** attached to the soft tissues **F**.

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and described in the following written specification. It is understood that no limitation to the scope of the invention is thereby intended. It is further understood that the present invention includes any alterations and modifications to the illustrated embodiments and includes further applications of the principles of the invention as would normally occur to one skilled in the art to which this invention pertains.